GEOLOGICAL NOTES

The Gualala River system and surrounding topography evolved in response to rapid geologic changes along the west coast of North America over the past 30 million years, and especially in the last 5 million years. The drainage networks evolved along with the changing landscape. The drainage network of the Gualala River is bedrock controlled and records the major geologic changes that took place. The landscape continues to change most notably by mass wasting. Mass wasting and erosion affect fluvial geomorphic conditions, which in turn affect aquatic habitat conditions.

In the Gualala watershed, the distribution of landslides, channel types, and sediment is primarily controlled by distribution and physical properties of the various geologic formations that form the foundation of the watershed. Understanding those background relationships can aid in the identification of operative processes, such as channel change.

Over the past 5-20 million years, much of the region was uplifted. As it was raised and tilted, the rivers incised into bedrock in many places. Large portions of the Gualala River system are incised into heterogeneous bedrock. The bedrock is composed of several rock formations of very different properties that have been juxtaposed in a complicated pattern through multiple generations of folding, faulting, uplift, and subsidence - many of which remain evident in the topography. The resistance of the bedrock to erosion is extremely variable and depends in many ways on the rock composition and the degree of deformation. As the bedrock was uplifted, crushed, and redistributed along active faults, the Gualala River system concurrently evolved. The network of watercourses followed paths of least resistance across the landscape as determined by the distribution of hard, durable rock versus soft, easily erodible rock. Many watercourses lengthened favorably along the weakened rock within fault zones. Many of the streams in the Gualala River watershed and surrounding area are clearly fault controlled. All the faults, with the exception of the San Andreas Fault are now considered inactive. The Tombs Creek Fault System was probably active during the Pleistocene (10,000 - 1.1 million years ago).

The present landscape in the Gualala River watershed continues to change through the processes of erosion and mass wasting in ways that force the stream channels to continually adjust. The timescale over which these changes occur vary from years to millennia. The forces of erosion work against the weaker rocks moving them down into the stream channels in the form of landslides. Streams erode into bedrock forming canyons. The local strength of the bedrock determines the steepness of the canyons. Over the long term, the canyon slopes steepen to a threshold at which there is quasi-equilibrium between continued steepening and mass wasting. For example, steep canyons form where bedrock is harder and resistant. Where uplift and incision outpaced mass wasting, the slopes are oversteepened. Shallow landsliding is common in many of the steep canyons in the watershed as equilibrium is gradually established. In many areas, large landslides are obstacles that cause the streams to change course and grade. Even in areas where faulting and landsliding are dormant, the resultant distribution of varying rock types still determines stream channel processes.

Historically active landslides (movement within the last 150 years) comprise approximately 10% of the watershed, while dormant landslides constitute approximately another 25%. Large earthflows (approximately one-third of which are historically active) and gullies occur dominantly east of the Tombs Creek Fault zone and in the southern portion of the watershed. Gullies typically erode the surface of the earthflows. Rock slides, debris slides, and debris flows occur dominantly in the rocks of Coastal Terrane where slopes are steep as in the North Fork subbasin and the Fuller Creek subbasin of the Wheatfield Fork. Large dormant rock slides (no movement within the last 150 years and in some cases movement thousands of years ago) occur along the San Andreas Fault zone and the Tombs Creek Fault zone. The companion CGS report titled, The Geologic and Geomorphic Characteristics of the Gualala River Watershed provides additional information including landsliding and mass wasting processes and the relationship to sediment in the stream channels of the Gualala River watershed.

IMPORTANT NOTES

1) The landslides and geomorphic features were mapped from the following sets of aerial photographs: 1984 WAC aerial photographs, nominal scale 1:31,680; 1999 WAC aerial photographs (Sonoma County), nominal scale 1:24,000; and 2000 WAC aerial photographs (Mendocino County), nominal scale 1:24,000. Field verification of landslide and geomorphic features was very limited and mapping relied primarily on interpretation of aerial photographs.

2) The geology depicted on this map was modified from several sources ranging in scale from 1:24,000 to 1:250,000 (see references). The source of the majority of the geology for the watershed (Sonoma County portion) was mapped at a scale of 1:62,500 (Huffman and Armstrong, 1980). Although the geology is presented in this map at a scale of 1:24,000, the detail and accuracy of the geologic data are limited to the spatial resolution of the 1:62,500 scale (and other scales of the source data) in which the digital database was originally compiled.

3) Landslides shown on this map have been divided into groups based on the clarity of their morphology and inferred type of movement. The landslides are also classified according to the certainty of their existence as determined by analysis of aerial photographs. The various landslide designations are not intended to, nor should they be interpreted to imply, the relative stability of slopes involved. See Plate 2 for relative landslide potential of the area.

4) The scale of this map limits the delineation of some features, and the map should not be substituted for site-specific studies.

5) Information on this map is not sufficient to serve as a substitute for the geologic and geotechnical site investigations required under Chapters 7.5 and 7.8 of Division 2 of the California Public Resources Code.

6) Historical mapping by DMG (Davenport, 1984, Open-File Report 84-48) was considered and incorporated using current interpretive protocols for identifying and classifying geomorphic features and/or landslides. Historical mapping added directly to the Gualala River watershed database is referenced in that electronic database with a citation to the North Coast Watersheds Mapping, digital compilation DMG CD 99-002 (DMG, 1999), which includes Open-File Report 84-48.

7) All small landslides (depicted on the map as points) from the 1984, 1999/2000 aerial photograph sets and DMG Open-File Report 84-48 (Davenport, 1984) are shown on the map.

8) Digital data shown on this map as well as additional landslide and fluvial geomorphology data are available from the following sources: on the CGS website at www.conservation.ca.gov/cgs, on compact disc from CGS (CD - ROM 2002 - 08), or on the North Coast Watershed Assessment Program website at www.ncwatershed.ca.gov.

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EROS Data Center, U.S. Geological Survey, various dates, Digital Elevation Models, 10 meter resolution.

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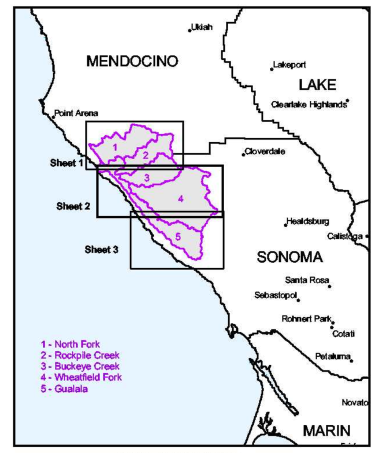
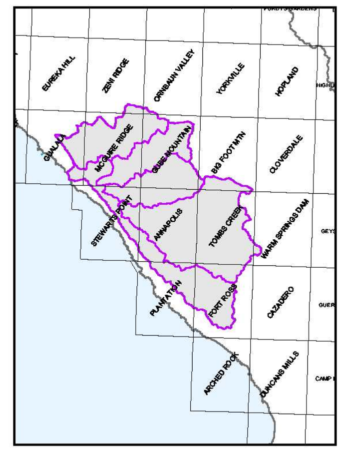
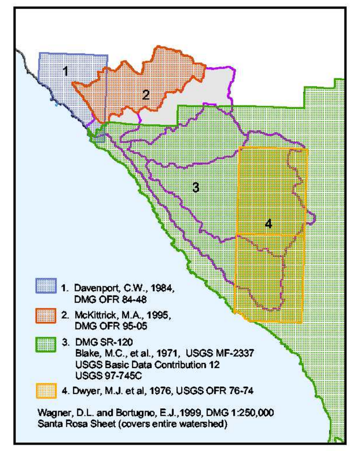
WAC, Inc., 2000, black and white aerial photographs for Mendocino County, flight 3, frames 160- 167, 186-190, 215-219, nominal scale 1:24,000, dated April 2, 2000.



INDEX TO SUBBASINS



INDEX TO USGS 7.5' QUADRANGLES



INDEX TO GEOLOGIC AND GEOMORPHIC MAPPING REFERENCES

Surficial Deposits (Holocene-Pleistocene)

Unit	Description
Qbs	**Beach sand**- marine-laid deposits of fine-to coarse-grained sand and gravel; may migrate seasonally.
Qf	**Alluvial fan**- characteristic fan-cone shapes at the mouths of eroding stream canyons; includes debris fans.
Qmt	**Marine terrace deposits**
Qscu	**Undifferentiated stream channel deposits**- unconsolidated sediments in active channels and flood plains.
Qsc1	**Stream channel deposits**- stage/return period 5 years or less
Qrt	**River terrace deposits**
Qoal	**Older alluvium**

Overlap (Quaternary-Tertiary)

Unit	Description
QTors	**Ohlson Ranch Formation**- siltstone.
QTorc	**Ohlson Ranch Formation**- conglomerate.
QTor	**Ohlson Ranch Formation**- undifferentiated Marine sandstone and conglomerate.

Gualala Block (Tertiary-Cretaceous)

Unit	Description
TKu	**Undifferentiated strata of German Rancho, Anchor Bay and Stewarts Point**- sandstone, siltstone, claystone and conglomerate.
Tg	**German Rancho Formation**- marine sandstone and mudstone.
Tsm	**Monterey Group**- marine sandstone and shale.
Ka	**Gualala Formation, Anchor Bay Member**- sandstone, mudstone and conglomerate.
Ks	**Gualala Formation, Stewarts Point Member**- sandstone, conglomerate and mudstone.
Ksb	**Black Point Spilite**

Undifferentiated Franciscan Complex (Cretaceous)

Unit	Description
Kfgs	**Greenstone**
Kfss	**Sandstone**
sp	**Serpentinite**
m	**Metamorphic**

Coastal Belt Franciscan, includes Coastal Terrane (Eocene-Early Cretaceous)

Unit	Description
TKfss	**Coastal Belt Franciscan**- marine sandstone.
TKfs	**Coastal Belt Franciscan**- marine siltstone.

Central Belt Franciscan, includes Central Terrane (Cretaceous)

Unit	Description
KJfs	**Undifferentiated Central Belt Franciscan**- siltstone.

Eastern Belt Franciscan, includes Yolla Bolly and Pickett Peak Terranes (Early Cretaceous-Late Jurassic)

Unit	Description
Jfmg	**Melange**
KJfm	**Central Belt Franciscan**- melange: includes chert- ch, greenstone- gs, greywacke- gwy and sandstone- ss.

Great Valley Complex (Cretaceous)

Unit	Description
KJgvs	**Sandstone and claystone**

ROCK SLIDE: Slope movement with bedrock as its primary source material. This class of failure includes rotational and translational landslides; relatively cohesive slide masses with failure planes that are deep-seated in comparison to those debris slides of similar areal extent. The slide plane is curved in a rotational slide. Movement along a planar joint or bedding surface may be referred to as translational. Complex versions with combinations of rotational heads and translational movement or earthflows downslope are common. indicates a scarp; arrows show direction of movement; queried where the presence of the slide is uncertain; boundary is solid where historically active, dashed where dormant, queried where uncertain.

EARTHFLOW: Slow to rapid movement of mostly fine-grained soil with some rocky debris in a semi-viscous, highly plastic state. After initial failure, the mass may flow or creep seasonally in response to changes in groundwater level. These types of slope failures often include complexes of nested rotational slides and deeply incised gullies; boundaries are usually indistinct. indicates a scarp; arrow indicates direction of movement; queried where the presence of the slide is uncertain. Boundary is solid where historically active, dashed where dormant, queried where uncertain.

DEBRIS SLIDE: Mass of unconsolidated rock, colluvium, and coarse-grained soil that has moved slowly to rapidly downslope along a relatively steep, shallow, translational failure plane. Debris slides form steep, unvegetated scars in the head region and possibly irregular, hummocky deposits in the toe region. Scars commonly ravel and remain unvegetated for several seasons depending on slope aspect. Queried where the presence of the slide is uncertain. Boundary is solid where historically active, queried where uncertain.

DEBRIS FLOW / TORRENT TRACK: Long stretches of bare ground that have been scoured and eroded to bedrock by extremely rapid movement of water-laden debris. Debris flows are commonly triggered by debris sliding in the source area during high intensity rains. Debris is often deposited downslope as a tangled mass of organic material in a matrix of rock and soil; debris may be reworked and incorporated into subsequent events; lack of vegetation indicates recent activity. Queried where the presence of the slide is uncertain. Boundary is solid where historically active, dashed where dormant, queried where uncertain.

SMALL LANDSLIDE: Landslide too small to delineate at 1:24,000 scale (typically less than 1/5 acre in area or less than 150 feet in length).

DISRUPTED GROUND: Irregular ground surface caused by complex landsliding processes resulting in features that are indistinguishable or too small to delineate individually at 1:24,000 scale; also may include areas affected by downslope creep, expansive soils, and/or gully erosion. Boundaries are usually indistinct.

DEBRIS SLIDE SLOPE / SOURCE AREA: A geomorphic feature characterized by steep, usually well vegetated slopes that appear to have been sculpted by numerous debris slides and debris flows. Upper reaches (source areas) of these slopes are often tightly concave and very steep. Soil and colluvium atop bedrock may be disrupted by active debris slides and debris flows. Slopes near the angle of repose may be relatively stable except where weak bedding planes, bedrock joints and fractures parallel the slope.

INNER GORGE: A geomorphic feature consisting of steep slopes adjacent to channels. The gorge typically is created by accelerated downcutting in response to regional uplift. It is defined as an area of streambank between the channel and the first break in slope. Line is queried where uncertain, or broken into segments to represent a stretch of discontinuous inner gorge too small to accurately represent at 1:24,000 scale. One-sided hachures indicate inner gorge on one side of channel only; hachures point downslope.

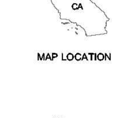
GULLY: Distinct, narrow channels formed by erosion of soil or soft rock material by running water. Channels are larger and deeper than rills and usually carry water only during and immediately after heavy rain or following the melting of ice or snow. Arrows point downhill; line is queried where uncertain.

Lithologic Contact: Solid where location is certain, dashed where approximately located or inferred, dotted where concealed, and queried where continuation or existence is uncertain.

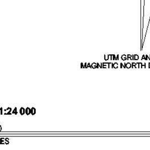
Fault: Solid where location is certain, dashed where approximately located or inferred, dotted where concealed, and queried where continuation or existence is uncertain.

Lineament: Linear feature of unknown origin noted on aerial photographs.

Watershed Boundary
Subbasin Boundary
County Boundary
Public Land Survey System
Stream
Primary Highway
Secondary Highway
Road, Street or Trail
City or Town
Spring



MAP LOCATION



UTM GRID AND 2002 MAGNETIC NORTH DECLINATION

SCALE 1:24 000

MILES 1 0.5 0 1
FEET 1000 500 0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10000
KILOMETERS 1 0.5 0 1 2
METERS 1000 0 1000 2000

CONTOUR INTERVAL 40 FEET

North American Datum of 1983 (NAD83)
Projection: Universal Transverse Mercator, Zone 10

DATA SOURCES

Watershed Boundaries	1:24,000 California Watershed Map (CALWATER v.2.2a)
Hydrography	1:24,000 USGS DLG and USFS CFF
Transportation	1:24,000 USGS DLG and USFS CFF
Hypsography	1:24,000 USGS DLG
Public Land Survey System	1:100,000 USGS DLG
County Boundaries	1:100,000 USGS DLG

GEOLOGIC AND GEOMORPHIC FEATURES RELATED TO LANDSLIDING
GUALALA RIVER WATERSHED, SONOMA AND MENDOCINO COUNTIES, CALIFORNIA
PLATE 1, SHEET 2 OF 3 (CENTRAL PORTION)

Michael S. Fuller, CEG, Wayne D. Haydon, CEG, Michael G. Purcell, RG and Kit Custis, CEG, CHG

Digital Representation by Sandra M. Summers and Peter D. Roffers

2002

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Information on this map is not sufficient to serve as a substitute for the geologic and geotechnical site investigations required under Chapters 7.5 and 7.8 of Division 2 of the California Public Resources Code.